SPECIFICATION

TITLE OF THE INVENTION

Method and System for Estimating Visceral Fat Area

BACKGROUND OF THE INVENTION

(i) Field of the Invention

The present invention relates to a method and system for estimating a visceral fat area. More specifically, it relates to a method and system for estimating a value indicating visceral fat area of a subject based on values each indicating height and fat mass of the subject.

(ii) Description of the Related Art

In recent years, accumulation of visceral fat has been receiving attention as a factor which exerts a significant influence on health and causes the onset of a lifestyle-related disease. An example of means for knowing accumulation of visceral fat is a method for estimating a visceral fat area by means of X-ray CT. However, to practice the method, assistance of a radiological technician is essential due to use of X-rays. This keeps the method from being widely used. Further, the method cannot be said to be favorable in that it causes an subject to be exposed to X-rays. In addition, the method also has a problem that its operation costs are excessively high.

Meanwhile, there is a correlation between an abdominal circumference on a navel and a visceral fat area, and there is a method for estimating a visceral fat area by use of the correlation. However, a measurement value of the abdominal circumference on the navel is significantly influenced by where the circumference is measured, a degree of tension in the abdominal part, timing of the measurement, i.e., before or after meal, and a condition of an subject such as a position of the subject. Therefore, when a visceral fat area is to be estimated based on only the measurement value or with emphasis on the measurement

value, the estimation is liable to be influenced by the above measurement conditions. Further, when a subject tries to measure a abdominal circumference on a navel by himself/herself, the subject is liable to tense his/her abdominal part at the time of the measurement or make the measurement off a proper position.

In order to resolve such weak points in the known methods as mentioned above, one of the present inventor has invented method and system for estimating visceral fat area of a subject by using certain equation(s) which takes a height, weight, fat mass and age of the subject as parameters, and filed as Japanese Patent Application No. 2001-212790 (Japanese Patent Publication No. 2003-24303) and United States Patent Application No. 10/193,281.

In case of the above equation(s), however, it was found in subsequent researches of the present inventors that estimation errors might often occur in the estimation for visceral fat area of a tall subject by an inferable reason that the fat mass is directly used as an explanation variable in the equation(s), even if it includes a correction term of height.

Fig. 18A shows a correlation graph between a fat mass measured by using the well known Bioelectrical Impedance Analysis (hereinafter referred to as the "BIA") in the horizontal axis and a visceral fat area measured by using the X-ray CT in the vertical axis. Measured data of numbers of subjects are plotted in the graph; in particular the measured data of tall subjects over 180cm are plotted as ■ mark. The line in the graph means an equation for estimating a visceral fat area having a parameter of fat mass as an explanation variable, which is acquired from the measured data. In case of the tall subjects, a visceral fat area estimated by using the equation is far different from the same measured by using the X-ray CT.

Fig. 18B shows a correlation graph between a body fat percentage measured by using the BIA in the horizontal axis and a visceral fat area measured by using the X-ray CT in the vertical axis. Namely, the line in the graph means an equation for estimating a visceral fat area having a parameter of

body fat percentage as an explanation variable. In case of the tall subjects, also a visceral fat area estimated by using the equation is far different from the same measured by using the X-ray CT.

One instance of problems, the estimation errors on the tall subjects may prevent that a plural of nations each having the different average of height can use a common equation for estimating a visceral fat area. Therefore, it is required to prepare a plural of method and system adequate for estimating a visceral fat area of each nation, thereby caused an increase in costs of development and manufacturing.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a method and system for estimating a visceral fat area having a potential to decrease the estimation errors due to height, and with which anyone can estimate a visceral fat area securely without concern for exposure to X-rays, at low costs, and with proper accuracy.

According to one aspect of the present invention, there is provided a method for estimating visceral fat area of a subject comprising steps of acquiring predetermined biological data of the subject including at least values each indicating height and fat mass of the subject and estimating a value indicating visceral fat area of the subject based on the acquired biological data, wherein the estimation of the value indicating visceral fat area is performed by using the product of the Xth power of the height value and the Yth power of the fat mass value, where each of the X and the Y expresses a number excluding zero.

According to one embodiment of the present invention, there is provided the method mentioned above, wherein the estimation of the value indicating visceral fat area is performed by using a parameter expressed as FM/Ht^2, where the Ht expresses the value indicating height and the FM expresses the value indicating fat mass.

According to another embodiment of the present invention, there is provided the method mentioned above, wherein the estimation of the value indicating visceral fat area is performed by using a parameter expressed as Ht^2/FM, where the Ht expresses the value indicating height and the FM expresses the value indicating fat mass.

According to further preferred embodiment of the present invention, there is provided the method mentioned above, wherein a value indicating age of the subject is further acquired in the step of acquiring the biological data and wherein the estimation of the value indicating visceral fat area is performed by using an

equation (1) expressed as below,

$$VFA = C11*FM/Ht^2 + C12*Age + C13 \quad (1)$$

where the VFA expresses the value indicating visceral fat mass, the Age expresses the value indicating age, and the C11, C12 and C13 each expresses constant.

According to another preferred embodiment of the present invention, there is provided the method mentioned above, wherein a value indicating age of the subject is further acquired in the step of acquiring the biological data and wherein the estimation of the value indicating visceral fat area is performed by using an equation (2) expressed as below,

$$VFA = C21*Ht^2/FM + C22*Age + C23 \quad (2)$$

where the VFA expresses the value indicating visceral fat mass, the Age expresses the value indicating age, and the C21, C22 and C23 each expresses constant.

According to another preferred embodiment of the present invention, there is provided the method mentioned above, wherein values each indicating age and weight of the subject are further acquired in the step of acquiring the biological data and wherein the estimation of the value indicating visceral fat area is performed by using an equation (3) expressed as below,

$$VFA = C31*FM/Ht^2 + C32*Age + C33*Wt/Ht^2 + C34 \quad (3)$$

where the VFA expresses the value indicating visceral fat mass, the Age expresses the value indicating age, the Wt expresses the value indicating weight, and the C31, C32, C33 and C34 each expresses constant.

According to another preferred embodiment of the present invention, there is provided the method mentioned above, wherein values each indicating age and weight of the subject are further acquired in the step of acquiring the biological data and wherein the estimation of the value indicating visceral fat area

is performed by using an equation (4) expressed as below,

$$VFA = C41*Ht^2/FM + C42*Age + C43*Wt/Ht^2 + C44 \qquad (4)$$

where the VFA expresses the value indicating visceral fat mass, the Age expresses the value indicating age, the Wt expresses the value indicating weight, and the C41, C42, C43 and C44 each expresses constant.

According to another preferred embodiment of the present invention, there is provided the method mentioned above, wherein values each indicating age and body fat percentage of the subject are further acquired in the step of acquiring the biological data and wherein the estimation of the value indicating visceral fat area is performed by using an equation (5) expressed as below,

$$VFA = C51*FM/Ht^2 + C52*Age + C53*\%FAT + C54 \qquad (5)$$

where the VFA expresses the value indicating visceral fat mass, the Age expresses the value indicating age, the %FAT expresses the value indicating body fat percentage, and the C51, C52, C53 and C54 each expresses constant.

According to another preferred embodiment of the present invention, there is provided the method mentioned above, wherein values each indicating age and body fat percentage of the subject are further acquired in the step of acquiring the biological data and wherein the estimation of the value indicating visceral fat area is performed by using an equation (6) expressed as below,

$$VFA = C61*Ht^2/FM + C62*Age + C63*\%FAT + C64 \qquad (6)$$

where the VFA expresses the value indicating visceral fat mass, the Age expresses the value indicating age, the %FAT expresses the value indicating body fat percentage, and the C61, C62, C63 and C64 each expresses constant.

According to further preferred embodiment of the present invention, there is provided the method mentioned above, wherein the value indicating fat mass of the subject is acquired by using the BIA (Bioelectrical Impedance Analysis) in the step of acquiring the biological data.

According to another aspect of the present invention, there is provided a system for estimating visceral fat area of a subject comprising a data acquiring component for acquiring predetermined biological data of the subject including at least values each indicating height and fat mass of the subject and a data processing component for estimating a value indicating visceral fat area of the subject based on the acquired biological data,
wherein the data processing component estimates the value indicating visceral fat area by using the product of the Xth power of the height value and the Yth power of the fat mass value, where each of the X and the Y expresses a number excluding zero.

According to one embodiment of the present invention, there is provided the system mentioned above, wherein the data processing component estimates the value indicating visceral fat area by using a parameter expressed as FM/Ht^2, where the Ht expresses the value indicating height and the FM expresses the value indicating fat mass.

According to another embodiment of the present invention, there is provided the system mentioned above, wherein the data processing component estimates the value indicating visceral fat area by using a parameter expressed as Ht^2/FM, where the Ht expresses the value indicating height and the FM expresses the value indicating fat mass.

According to further preferred embodiment of the present invention, there is provided the system mentioned above, wherein the data acquiring component further acquires a value indicating age of the subject and wherein the data processing component estimates the value indicating visceral fat area by using an equation (1) expressed as below,

$$VFA = C11*FM/Ht^2 + C12*Age + C13 \quad (1)$$

where the VFA expresses the value indicating visceral fat mass, the Age

expresses the value indicating age, and the C11, C12 and C13 each expresses constant.

According to another preferred embodiment of the present invention, there is provided the system mentioned above, wherein the data acquiring component further acquires a value indicating age of the subject and wherein the data processing component estimates the value indicating visceral fat area by using an equation (2) expressed as below,

$$VFA = C21*Ht^2/FM + C22*Age + C23 \quad (2)$$

where the VFA expresses the value indicating visceral fat mass, the Age expresses the value indicating age, and the C21, C22 and C23 each expresses constant.

According to another preferred embodiment of the present invention, there is provided the system mentioned above, wherein the data acquiring component further acquires values each indicating age and weight of the subject and wherein the data processing component estimates the value indicating visceral fat area by using an equation (3) expressed as below,

$$VFA = C31*FM/Ht^2 + C32*Age + C33*Wt/Ht^2 + C34 \quad (3)$$

where the VFA expresses the value indicating visceral fat mass, the Age expresses the value indicating age, the Wt expresses the value indicating weight, and the C31, C32, C33 and C34 each expresses constant.

According to another preferred embodiment of the present invention, there is provided the system mentioned above, wherein the data acquiring component further acquires values each indicating age and weight of the subject and wherein the data processing component estimates the value indicating visceral fat area by using an equation (4) expressed as below,

$$VFA = C41*Ht^2/FM + C42*Age + C43*Wt/Ht^2 + C44 \quad (4)$$

where the VFA expresses the value indicating visceral fat mass, the Age

expresses the value indicating age, the Wt expresses the value indicating weight, and the C41, C42, C43 and C44 each expresses constant.

According to another preferred embodiment of the present invention, there is provided the system mentioned above, wherein the data acquiring component further acquires values each indicating age and body fat percentage of the subject and wherein the data processing component estimates the value indicating visceral fat area by using an equation (5) expressed as below,

$$VFA = C51*FM/Ht^2 + C52*Age + C53*\%FAT + C54 \qquad (5)$$

where the VFA expresses the value indicating visceral fat mass, the Age expresses the value indicating age, the %FAT expresses the value indicating body fat percentage, and the C51, C52, C53 and C54 each expresses constant.

According to another preferred embodiment of the present invention, there is provided the system mentioned above, wherein the data acquiring component further acquires values each indicating age and body fat percentage of the subject and wherein the data processing component estimates the value indicating visceral fat area by using an equation (6) expressed as below,

$$VFA = C61*Ht^2/FM + C62*Age + C63*\%FAT + C64 \qquad (6)$$

where the VFA expresses the value indicating visceral fat mass, the Age expresses the value indicating age, the %FAT expresses the value indicating body fat percentage, and the C61, C62, C63 and C64 each expresses constant.

According to further preferred embodiment of the present invention, there is provided the system mentioned above, wherein the value indicating fat mass of the subject is acquired by the data acquiring component based on the BIA (Bioelectrical Impedance Analysis).

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a graph showing a correlation between the parameter FM/Ht^2 and a visceral fat area measured by the X-ray CT.

Fig. 2 is a graph showing a correlation between the parameter Ht^2/FM and a visceral fat area measured by the X-ray CT.

Fig. 3 is a graph showing a correlation between a visceral fat area estimated by the equation (1) and a visceral fat area measured by the X-ray CT.

Fig. 4 is a graph showing a correlation between a visceral fat area estimated by the equation (2) and a visceral fat area measured by the X-ray CT.

Fig. 5 is a graph showing a correlation between a visceral fat area estimated by the equation (3) and a visceral fat area measured by the X-ray CT.

Fig. 6 is a graph showing a correlation between a visceral fat area estimated by the equation (4) and a visceral fat area measured by the X-ray CT.

Fig. 7 is a graph showing a correlation between a visceral fat area estimated by the equation (5) and a visceral fat area measured by the X-ray CT.

Fig. 8 is a graph showing a correlation between a visceral fat area estimated by the equation (6) and a visceral fat area measured by the X-ray CT.

Fig. 9 is a schematic view showing an external appearance of a visceral fat area estimating system as one embodiment of the present invention.

Fig. 10 is a block diagram showing an electric circuit arrangement of the system of Fig. 9.

Fig. 11 is a flowchart illustrating steps to be performed by the system of Fig. 9.

Fig. 12 is an example of display of the system of Fig. 9.

Fig. 13A is a schematic view showing an external appearance of a visceral fat area estimating system as another embodiment of the present invention.

Fig. 13B is a schematic view showing a use of the system of Fig. 13A.

Fig. 14 is a block diagram showing an electric circuit arrangement of the

system of Fig. 13A.

Fig. 15 is a flowchart illustrating steps to be performed by the system of Fig. 13A.

Fig. 16 is an example of display of the system of Fig. 13A.

Fig. 17 is another example of display of the system of Fig. 13A.

Fig. 18A is a graph showing a correlation between a fat mass measured by the BIA and a visceral fat area measured by the X-ray CT.

Fig. 18B is a graph showing a correlation between a body fat percentage measured by the BIA and a visceral fat area measured by the X-ray CT.

Reference numerals 1 and 60 denote a visceral fat area estimating system; 2 a platform; 3a, 3b, 58a and 58b a current-carrying electrode; 4a, 4b, 59a and 59b a measuring electrode; 5a an UP key; 5b a DOWN key; 6 a setting key; 7a to 7e a personal key; 9 a display unit; 10 an electrode switching unit; 15 a weight sensor; 20 an electronic circuit board; 21 a high frequency constant current circuit; 22 a voltage measuring circuit; 23 an A/D converter; 24 a microprocessor; and 25 a memory.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Embodiments of the present invention will be described in detail with reference to the attached drawings.

Firstly, a method for estimating a visceral fat area which underlies the present invention will be described.

It has been found in the recent researches of the present inventors that a visceral fat area correlates closely with a parameter of corrected fat mass directly by height. The present invention provides a method for estimating a visceral fat area relying upon the correlation, in particular by using the product of the Xth power of the height value and the Yth power of the fat mass value, where the X and the Y each expresses a number excluding zero.

The present inventors measured a height (Ht), a fat mass (FM) and a visceral fat area (VFA) of a number of subjects, and then worked out a natural logarithm equation as expressed $LN(VFA) = X*Ht + Y*FM$ by substituting the measured data for the equation so as to seek and determine the numbers applicable to the X and the Y. Incidentally, the BIA was used for measuring the fat mass of the subjects, and the X-ray CT was used for measuring the visceral fat area of the subjects.

As a result of this effort, -2 and 1 were determined as applicable numbers for each of the X and the Y. In this regard, it has been confirmed as shown in Fig. 1 that the visceral fat area (VFA) correlates closely with a parameter FM/Ht^2 (namely, $X = -2$ and $Y = 1$), regardless of height of the subjects. Therefore, the estimation of visceral fat area to be performed by using a parameter expressed as FM/Ht^2 is desirable and preferable for decreasing the estimation errors due to height.

Also 2 and -1 were determined as alternative applicable numbers for each of the X and the Y. In this regard, it has also been confirmed as shown in Fig. 2 that the visceral fat area (VFA) correlates closely with a parameter Ht^2/FM (namely, $X = 2$ and $Y = -1$), regardless of height of the subjects. Therefore, the

estimation of visceral fat area performed by using a parameter expressed as Ht^2/FM is desirable and preferable for decreasing the estimating errors due to height.

Further, the present inventors measured a correlation between an age (Age) and the visceral fat area those are of the numbers of subjects, and then performed a multiple regression analysis based on the correlation between the age and the visceral fat area and the correlation between the parameter FM/Ht^2 and the visceral fat area as shown in Fig. 1. As a result of this effort, an equation (1) as expressed below, where the C11, C12 and C13 each expresses constant (concretely, C11 = 6.05 to 22.15 for male or 3.78 to 20.89 for female, C12 = 0.00 to 4.13 for male or 0.00 to 3.17 for female, and C13 = -80.96 to -9.80 for male or -81.57 to -2.72 for female), was sought and determined.

$$VFA = C11 * FM/Ht^2 + C12 * Age + C13 \quad (1)$$

It has been confirmed as shown in Fig. 3 that a visceral fat area estimated by using the equation (1) correlates highly with the visceral fat area measured by the X-ray CT. Therefore, the estimation of visceral fat area performed by using the equation (1) is further desirable and preferable for decreasing the estimating errors due to height.

Further, the present inventors performed a multiple regression analysis based on the correlation between the age and the visceral fat area and the correlation between the parameter Ht^2/FM and the visceral fat area as shown in Fig. 2. As a result of this effort, an equation (2) as expressed below, where the C21, C22 and C23 each expresses constant (concretely, C21 = -286.30 to -107.80 for male or -576.42 to -107.80 for female, C22 = 0.00 to 4.02 for male or 0.00 to 4.02 for female, and C23 = 22.00 to 122.78 for male or 32.03 to 122.78 for female), was sought and determined.

$$VFA = C21 * Ht^2/FM + C22 * Age + C23 \quad (2)$$

It has been confirmed as shown in Fig. 4 that a visceral fat area estimated by using the equation (2) correlates highly with the visceral fat area

measured by the X-ray CT. Therefore, the estimation of visceral fat area performed by using the equation (2) is also desirable and preferable for decreasing the estimating errors due to height.

Further, the present inventors measured, in addition to the correlation between the age and the visceral fat area, a correlation between a body mass index which is well know as a quotient of a weight (Wt) over a square of a height (Ht^2) and the visceral fat area those are of the numbers of subjects, and then performed a multiple regression analysis based on the correlation between the age and the visceral fat area, the correlation between the body mass index (Wt/Ht^2) and the visceral fat area and the correlation between the parameter FM/Ht^2 and the visceral fat area as shown in Fig. 1. As a result of this effort, an equation (3) as expressed below, where the C31, C32, C33 and C34 each expresses constant (concretely, C31 = 2.96 to 20.36 for male or -2.91 to 15.39 for female, C32 = 0.00 to 4.12 for male or 0.00 to 4.45 for female, C33 = -2.77 to 7.43 for male or -2.77 to 7.43 for female, and C34 = -198.40 to -8.53 for male or -193.90 to -7.21 for female), was sought and determined.

$$VFA = C31*FM/Ht^2 + C32*Age + C33*Wt/Ht^2 + C34 \qquad (3)$$

It has been confirmed as shown in Fig. 5 that a visceral fat area estimated by using the equation (3) correlates highly with the visceral fat area measured by the X-ray CT. Therefore, the estimation of visceral fat area performed by using the equation (3) is also desirable and preferable for decreasing the estimating errors due to height.

Further, the present inventors performed a multiple regression analysis based on the correlation between the age and the visceral fat area, the correlation between the body mass index (Wt/Ht^2) and the visceral fat area and the correlation between the parameter Ht^2/FM and the visceral fat area as shown in Fig. 2. As a result of this effort, an equation (4) as expressed below, where the C41, C42, C43 and C44 each expresses constant (concretely, C41 = -196.60 to -3.88 for male or -206.89 to 61.71 for female, C42 = 0.00 to 4.05 for male or

0.00 to 4.12 for female, C43 = 0.18 to 16.43 for male or 0.14 to 8.11 for female, and C44 = -205.15 to -4.28 for male or -198.10 to -19.33 for female), was sought and determined.

$$VFA = C41*Ht^2/FM + C42*Age + C43*Wt/Ht^2 + C44 \qquad (4)$$

It has been confirmed as shown in Fig. 6 that a visceral fat area estimated by using the equation (4) correlates highly with the visceral fat area measured by the X-ray CT. Therefore, the estimation of visceral fat area performed by using the equation (4) is also desirable and preferable for decreasing the estimating errors due to height.

Further, the present inventors measured, in addition to the correlation between the age and the visceral fat area, a correlation between a body fat percentage (%FAT) and the visceral fat area those are of the numbers of subjects (cf. Fig. 18B), and then performed a multiple regression analysis based on the correlation between the age and the visceral fat area, the correlation between the body fat percentage (%FAT) and the visceral fat area and the correlation between the parameter FM/Ht^2 and the visceral fat area as shown in Fig. 1. As a result of this effort, an equation (5) as expressed below, where the C51, C52, C53 and C54 each expresses constant (concretely, C51 = 0.17 to 32.81 for male or -2.15 to 14.45 for female, C52 = 0.00 to 4.12 for male or 0.00 to 4.12 for female, C53 = -5.03 to 8.80 for male or 0.00 to 5.13 for female, and C54 = -121.25 to -5.74 for male or -104.24 to -7.43 for female), was sought and determined.

$$VFA = C51*FM/Ht^2 + C52*Age + C53*\%FAT + C54 \qquad (5)$$

It has been confirmed as shown in Fig. 7 that a visceral fat area estimated by using the equation (5) correlates highly with the visceral fat area measured by the X-ray CT. Therefore, the estimation of visceral fat area performed by using the equation (5) is also desirable and preferable for decreasing the estimating errors due to height.

Further, the present inventors performed a multiple regression analysis based on the correlation between the age and the visceral fat area, the

correlation between the body fat percentage (%FAT) and the visceral fat area and the correlation between the parameter Ht^2/FM and the visceral fat area as shown in Fig. 2. As a result of this effort, an equation (6) as expressed below, where the C61, C62, C63 and C64 each expresses constant (concretely, C61 = -107.96 to 154.97 for male or -216.05 to 139.62 for female, C62 = 0.00 to 4.10 for male or 0.00 to 2.08 for female, C63 = 1.00 to 14.15 for male or 0.08 to 15.14 for female, and C64 = -197.01 to -5.91 for male or -184.11 to -1.60 for female), was sought and determined.

$$VFA = C61*Ht^2/FM + C62*Age + C63*Wt/Ht^2 + C64 \qquad (6)$$

It has been confirmed as shown in Fig. 8 that a visceral fat area estimated by using the equation (6) correlates highly with the visceral fat area measured by the X-ray CT. Therefore, the estimation of visceral fat area performed by using the equation (6) is also desirable and preferable for decreasing the estimating errors due to height.

In and for the methods according to the present invention, the BIA is recommended as a simple and accurate manner for acquiring the fat mass of a subject. Also the other manners can be used, that includes for example the Under Water Weighing, the Dual Energy X-ray Absorptiometry, the Infrared Interactance, or the manner estimating the fat mass based on a body mass index or based on a subcutaneous fat measured by using a caliper or a ultrasound, those manners are well known.

It is also known that the above constants C11 to C64 vary according to personal parameters including intensity of daily activity (so called the "Physical Activity Level"), presence or absence of menstruation, age at the onset of menopause and/or the number of years elapsed after the onset of menopause, or the like. Therefore, when the constants are further adjusted or calibrated in accordance with such personal parameters, a visceral fat area can probably be estimated more accurately.

(Embodiment 1)

Next, a system for estimating a visceral fat area as one of the embodiments of the present invention as described above will be described.

Fig. 9 is a schematic view showing an external appearance of the visceral fat area estimating system. Fig. 10 is a block diagram showing an electric circuit arrangement of the system of Fig. 9. An estimating system 1 of the present embodiment has, on a weighing platform 2 of a scale, current-carrying electrodes 3a and 3b for forming a current path in a living body, measuring electrodes 4a and 4b for detecting a potential difference which occurs in the living body, a setting key 6 for setting personal data including a height, age and gender as well as time, an UP key 5a for incrementing a numerical value, a DOWN key 5b for decrementing a numerical value, personal keys 7a to 7e for making a measurement based on retrieved personal data, and a display unit 9 for displaying statuses of set conditions, results of measurements or results of determinations. Further, as shown in Fig. 10, inside the platform 2, a weight sensor 15 for detecting a load and converting it into an electric signal, an electronic circuit board 20 and the like are provided. The personal keys 7a to 7e and the setting key 6 also serve as a power switch. Upon press of any one of the personal keys 7a to 7e or the setting key 6, the system is activated. Meanwhile, the system is deactivated after passage of a certain period of time after a result of measurement is displayed or even during entry of data.

The electronic circuit board 20 has the display unit 9 provided on the platform 2, the setting key 6, the UP key 5a, the DOWN key 5b, a high frequency low current circuit 21 for applying a very weak constant current of high frequency to the current-carrying electrodes 3a and 3b, a voltage measuring circuit 22 for measuring a potential difference in a living body which occurs between the measuring electrodes 4a and 4b, an A/D conversion circuit 23 for converting an analog signal from the voltage measuring circuit 22 or weight sensor 15 into a digital signal, a memory 25 for storing set and registered conditions, measured

data and the like, and a microprocessor 24 for computing a percent body fat and the like based on measurement conditions, measured bioelectrical impedance data and body weight data and controlling. The electronic circuit board 20 is connected to each of the current-carrying electrodes 3a and 3b, measuring electrodes 4a and 4b, weight sensor 15 and personal keys 7a, 7b, 7c and 7d via an electric wire.

Fig. 11 is a flowchart illustrating steps for estimating a visceral fat area to be performed by the visceral fat area estimating system in the present embodiment. Hereinafter, an overall operation will be described with reference to the flowchart. STEPS S2 to S5 will be described briefly since these are prior arts. Upon press of any one of the personal keys 7a to 7e or the setting key 6, the system is activated. When the setting key 6 is pressed down, settings of personal data including a height, age and gender can be made. Meanwhile, when one of the personal keys is pressed down, personal data set by means of the setting key is read from the memory 25, and a measurement is made based on the data. In STEP S1, it is determined whether the setting key 6 has been pressed down. If a key other than the setting key 6 has been pressed down, the system proceeds to STEP S6. In STEP S2, a personal number to be set is entered. On the display unit 9, a personal number "1" is displayed. Each time the UP key 5a is pressed, the personal number is incremented by 1. Meanwhile, each time the DOWN key 5b is pressed, the personal number is decremented by 1. Upon press of the setting key 6, the personal number is set and then stored in the memory 25. In STEP S3, gender is entered and set in the same manner as the personal number has been set. In STEP S4, a height is set. In this STEP, since an initial value of the height is displayed on the display unit 9, the height value can be incremented and decremented by use of the UP key 5a and the DOWN key 5b, respectively. When the value reaches a desired value, the height value is confirmed by press of the setting key 6. In STEP S5, age is set in the same manner as the height has been set. Then, the program is

terminated.

In STEP S6, if none of the personal keys 7a to 7e has been pressed down, the system returns to STEP S1. In STEP S7, personal data such as gender and a height which corresponds to a pressed personal key is read from the memory 25 and displayed on the display unit 9 to encourage an subject to check whether he has pressed down a right personal key. In STEP S8, when the subject stands on the platform 2, his body weight is measured. In STEP S9, if a stable measurement value cannot be obtained, the system returns to STEP S8. In STEP S10, the weight value is stored in the memory 25.

In STEP S12, a bioelectrical impedance is measured in the following manner. That is, the high frequency constant current circuit 21 outputs a very weak constant current I of high frequency. This output current is applied to the subject via the current-carrying electrodes 3a and 3b. At this time, the current passing through the subject is detected by the voltage measuring circuit 22 as a potential difference in the living body which occurs between the measuring electrodes 4a and 4b. This analog output is converted to a digital signal V by the A/D converter 23. A bioelectrical impedance Z is determined by an equation $Z = V/I$. In STEP S13, if a stable measurement value cannot be obtained, the system returns to STEP S12. In STEP S14, the measured bioelectrical impedance value is stored in the memory 25.

Then, the system proceeds to STEP S15 in which a percent body fat is calculated from the body weight, the height and the bioelectrical impedance value measured in STEP S12. Description of a method for calculating the percent body fat will be omitted since it is known to those skilled in the art. To determine a fat mass, the body weight is multiplied by the percent body fat.

In STEP S16, a visceral fat area is estimated by using the equation (1). Needless to say, any of the equations (2) to (6) mentioned above can be used instead of the equation (1).

In STEP S17, as shown in Fig. 12, the measurement values and the

values calculated from the measurement values are displayed on the display unit 9.

In the above embodiment, a scale and an body fat meter are provided. However, in the case of an body fat meter such as a card-type body fat meter which is equipped with no scale, a body weight value can be entered manually by use of the UP key 5a, the DOWN key 5b and the setting key 6. In this case, average body weight values of a male and a female are stored in the memory in advance, and the numeric value is incremented or decremented by means of the UP key 5a and the DOWN key 5b and confirmed as a body weight of an subject by means of the setting key 6. Further, in the case of an ordinary calculator which is not equipped with a percent body fat meter, a percent body fat can be entered manually as in the case of the body weight value. As for a height value, although it is entered manually by means of the keys in the above embodiment, a height measuring device may be used to obtain the value.

According to definition of a percent body fat, a fat mass can be determined once a body weight and the percent body fat are determined. Therefore, if a conventional scale equipped with an body fat meter is available, all input variables of the equation (1) for estimating a visceral fat area can be determined, and a visceral fat area can be estimated by the estimation method of the present invention.

In the estimating system 1 of the above embodiment, a bioelectrical impedance between feet has been measured. However, the present invention is not limited to this, and a bioelectrical impedance between hands or between a hand and a foot may be measured instead.

(Embodiment 2)

Next, another embodiment of the present invention will be described. Fig. 13A is a schematic view showing an external configuration of a second embodiment of the visceral fat estimating system according to the present

invention, and Fig. 13B is a schematic view showing a use thereof. An estimating system 60 of the present embodiment is different from the first embodiment shown in Fig. 9 in that electrodes 56 and 57 for hands are additionally provided. The same constituents as those in the first embodiment are given the same reference numerals as those given to the constituents in the first embodiment. The electrode 56 for the left hand comprises a constant current applying electrode 58a and a voltage measuring electrode 59a. Similarly, the electrode 57 for the right hand comprises a constant current applying electrode 58b and a voltage measuring electrode 59b.

Fig. 14 is an electric block diagram of the estimating system 60 of the present embodiment. Eight electrodes which contact both hands and feet, i.e., electrodes 3a, 3b, 4a, 4b, 58a, 58b, 59a and 59b, are connected to an electrode switching unit 10. The electrode switching unit 10 is connected to a control unit 13 via the high frequency constant current circuit 21 and the voltage measuring circuit 22. The control unit 13 includes a microcomputer and is connected to a memory 25 for storing a variety of data.

Next, operations of the estimating system 60 of the present embodiment will be described with reference to a flowchart in Fig. 15. Steps for the same operations as those of steps shown in Fig. 11 are given the same step numbers as those given to the steps of Fig. 11. Descriptions of STEPS S1 to S10 will be omitted since they are the same as STEPS S1 to S10 in Fig. 11.

In STEP S21, the switching unit 10 is switched according to a direction from the control unit 13, whereby an alternating current is supplied from the high frequency constant current circuit 21 to the electrodes 3a and 3b, and voltages are measured at the electrodes 4a and 4b by the voltage measuring circuit 22. Then, the control unit 13 calculates a bioelectrical impedance (BI) from the measured voltages. Thus, BI is measured for a whole body and each of the following body parts, i.e., the right foot, the left foot, the right hand and the left hand. In STEP S22, if a stable measurement value cannot be obtained, the

system returns to STEP S21. In STEP S23, the measured BI values are stored in the memory 25.

In STEP S24, percent body fats and fat masses are calculated from the measured BIs. Firstly, a percent body fat and fat mass of the whole body are calculated from the BI of the whole body. Subsequently, a percent body fat, fat free mass and fat mass of each of the right foot, the left foot, the right hand and the left hand are calculated from the BI of each of the right foot, the left foot, the right hand and the left hand, respectively. Then, a total of the fat masses of the body parts is calculated. Thereafter, the total of the fat masses of the body parts is subtracted from the fat mass of the whole body so as to determine a fat mass of a trunk.

In STEP S25, a visceral fat area is estimated by using the equation (1). As the fat mass FM in the equation, the fat mass of the trunk is used. Also any of the equations (2) to (6) mentioned above can be used instead of the equation (1).

In STEP S26, as shown in Fig. 16 and Fig. 17, the measurement values and the values calculated from the measurement values are displayed on the display unit 9. In particular, Fig. 17 shows an example displaying a visceral fat level that is a value indicating a degree of accumulation of visceral fat. The visceral fat level of a user which is also estimated by using the equation (1), or any of the equations (2) to (6) as the case may be, is plotted as a star on a graph area having the vertical axis for the visceral fat level (VFL) and the horizontal axis for the age (AGE). For the purpose of enabling a user to easily recognize his/her visceral fat level, a standard (average) line indicating a standard visceral fat level estimated from a number of subjects is displayed on the graph area with and between its relevant lines which indicate for example the standard deviations or the maximum and minimum data.

As described above, in the method according to the present invention,

the estimation of the value indicating visceral fat area is performed by using the product of the Xth power of the height value and the Yth power of the fat mass value, preferably by using the parameter expressed as FM/Ht^2 or Ht^2/FM, more preferably by using one of the equations (1) to (6). There is consequently provided the method for estimating a visceral fat area having a potential to decrease the estimation errors due to height, and with which any one can estimate its visceral fat area securely without concern for exposure to X-rays, at low costs, and with proper accuracy.

In the system according to the present invention, the data processing unit estimates the value indicating visceral fat area by using the product of the Xth power of the height value and the Yth power of the fat mass value, preferably by using the parameter expressed as FM/Ht^2 or Ht^2/FM, more preferably by using one of the equations (1) to (6). There is consequently provided the system for estimating a visceral fat area having a potential to decrease the estimation errors due to height, and with which any one can estimate its visceral fat area securely without concern for exposure to X-rays, at low costs, and with proper accuracy.

Therefore, the method and system for estimating the value indicating visceral fat area can be used widely for the tall subjects as well as the short subjects, thereby allowed a common use by a number of nations each having the different average of height and caused a decrease in cost of development and manufacturing.